Director of INNOVATION

Innovation Beyond Imagination

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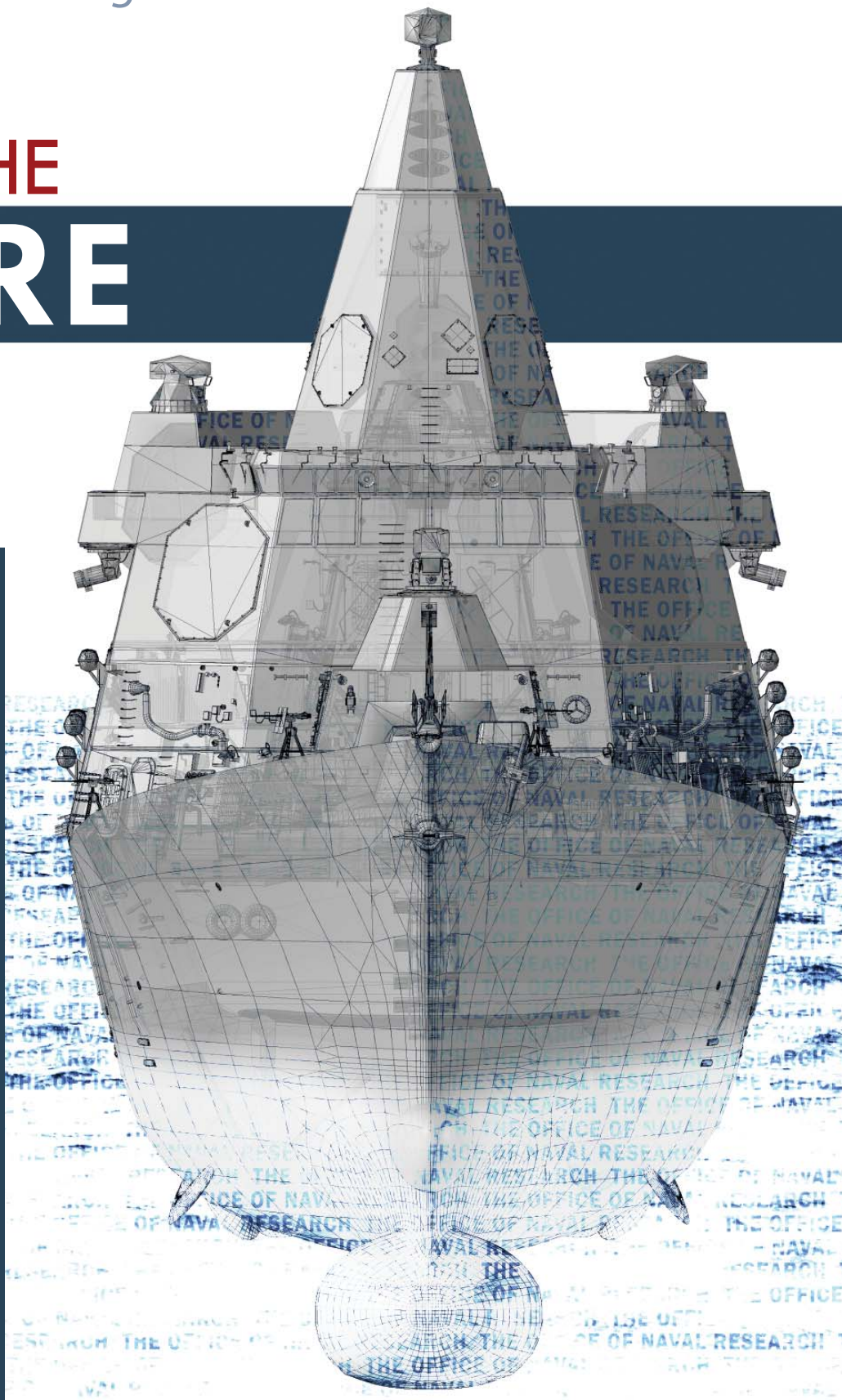
SHIP OF THE FUTURE



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SHIP OF THE FUTURE
OVERVIEW

Ms. Lindsey Gates – Analyst, Schafer Corporation in support of ONR Office of Innovation

Within any organization, it is vital to have a compelling message and means for conveying that message. The Director of Innovation's message at the Office of Naval Research (ONR) is to promote and foster groundbreaking science and technology (S&T) and to enable processes to facilitate innovation. Through the investigation and general use of open innovation, we realize that one way to promote disruptive breakthroughs is to foster multi-disciplinary collaboration and general situational awareness of the work going on in the surrounding S&T community. In order to promote this broad collaboration, ONR sponsored the development of the Ship of the Future touchscreen display.

Although it is only a piece of a much larger picture, the Ship of the Future touchscreen display is a proof of concept for a multimedia tool to expand outreach and internal situational awareness. Through an interactive interface, users are able to immerse themselves into a futuristic environment, providing them with the opportunity to explore technologies through text descriptions, images, videos and even animations of some technologies at work.

The concept for the Ship of the Future touchscreen display was the brainchild of ONR's former Command Master Chief Stephen French. As a Navy operator and TechSolutions[1] portfolio manager, he intimately understood the importance of translating ONR's S&T into meaningful applications that resonate with our Sailors and Marines. As the ultimate customers for everything we do, it is imperative to communicate to our warfighters how S&T can improve their daily lives and keep them safe when they're in the line of fire. From this perspective, CMC French believed that it was important to have a tool to communicate the impact that ONR's S&T research would ultimately have on the fleet, resulting in the decision to use a ship of the future as the initial naval platform to be illustrated with this tool.

Once the Ship of the Future development team decided on the ship of the future for the initial direction, we spent time brainstorming within ONR's Innovation team to determine the best technical interface and graphical representation for the ship. For ease of use, we decided on a touchscreen and found a stellar team of designers to assist in the endeavor. Working closely with the designers, representatives from the Ship Systems and Engineering division at ONR, and various Program Officers throughout the building we moved forward using an agile development process making rudder changes as necessary. After building the initial interface and in order to get external feedback, we unveiled the first phase of the Ship of the Future to participants at NDIA's Science, Engineering and Technology conference and to the public at New York City's 2010 Fleet Week.

[1] TechSolutions is one of ONR's conduits into the fleet, intended to provide rapid response and delivery of new technologies to our Sailors and Marines.

The feedback we got from these different groups of people was incredibly beneficial and highlighted a few aspects of the program to that point. We discovered that as long as a program was explained in a clear, concise manner and had images to show users how a particular technology worked, users became interested. Even technologies that would not be considered conventionally "exciting" received strong interest and feedback when coupled with specific metrics denoting success and images or videos showing the technology at work.

Although the display was initially intended for engagement with our partners throughout government, industry and academia, perhaps the most unanticipated response we received was from younger generations. Children and young adults attending the Fleet Week festivities gravitated toward the display. Surprisingly in many cases, it was the younger kids that asked questions about each of the technologies rather than their parents. There were multiple repeat visitors who wanted to bring their friends or family and show them what they had learned. In one particular instance, a woman who was graduating from a top university asked for information on career openings at ONR and NRL because she was so intrigued. With science, technology, engineering and mathematics (STEM) education outreach becoming a major initiative across the United States, it was great to see the impact that the display had on this group. The hands-on interaction with the display brought the S&T to life and users left wanting to learn more about many of the projects.

View of the command and control center

Alternative Ship of the Future Views that can been seen on the interactive touch screen — view of the ship's flight deck

After receiving such positive feedback on the initial fifteen technologies displayed, we began more extensive collaboration with all of the S&T departments in ONR, determining a set of nearly fifty technologies that span the breadth of ONR's purview. Ranging from weapon systems to tank coatings to life-saving medical tools, today the display gives users a glance at what ONR offers our warfighters in both the near- and far-term across the broad spectrum of S&T.

In order to promote innovation we are always looking for ways to broaden our engagement with expanded communities of interest. Multi-media and social medial tools like the Ship of the Future illustrate how basic research will ultimately impact our warfighter's lives. Eventually, we hope to incorporate more interactive elements that allow the user to experiment with technology trade space. The trade space feature will allow the research community to gain early decision support from the operating community writ large. The training and education community is constantly better prepared and more equipped because of their involvement in virtual worlds and the ability to walk through different scenarios prior to actually experiencing them in real life. As we continue to develop the Ship of the Future interactive platform we hope to see this type of tool as more of a capability, a way to help the operator become an early adopter, while also strengthening the program by increasing our ability to get concise, end-user feedback early on in the lifecycle of a technology. ■

SHIP OF THE FUTURE

1 ANTENNA APERTURE

The InTop Submarine SATCOM Antenna effort will provide the capability to simultaneously receive up to four different SATCOM signals from four different directions using a single antenna aperture.

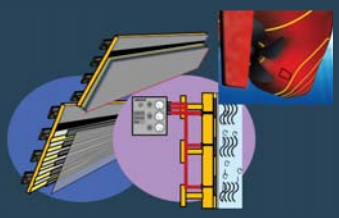
35 HOURS

Rapid Cure Tank Coatings take only 35 hours to install compared to the legacy coatings that take 216 hours which will reduce lifecycle cost and free up funds for other maintenance requirements.

Pictured: Application of this coating technology reduced the tank repair and preservation process by 28 days.

$2.44 BILLION/YEAR

Estimated Total Navy Ship Corrosion Costs



Maintenance Free Ship Technologies program is working several efforts to include the Underwater Hull Shield Technologies to alleviate this cost. The Underwater Hull Shield is a dynamic multifunctional ICCP system that provides a total underwater hull management system for corrosion and fouling control, and threat detection. Payoff is elimination of ship dry docking enabling increased Operational Availability and reduced Total Ownership Cost.

80 % OF A SHIP'S HULL

HullBUG – the Autonomous, tether-free, underwater vehicles that will maintain a fouling rating of 10 on anti-fouling and fouling-release coatings and grooms 80% of underwater hull surface area. The HullBUG provides a revolutionary semi-continuous "grooming" capability that prevents biofouling on ship hulls while in port. Maintaining ship hulls with minimal biofouling will yield significant cost savings from both reduction in fuel consumption and decreased maintenance.

25 MEGAJOULES MUZZLE ENERGY

Current world record for an electromagnetic railgun firing, set at the Naval Systems Warfare Center, Dahlgren Division, soon to be broken by the anticipated 32 megajoules shot on 10 December 2010.

1-5 SAILORS IN THE NAVY

suffer measurable hearing loss and tinnitus as a result of excessive noise levels. ONR's research into Noise Induced Hearing Loss is looking into new methods of protection and preventative measures in these loud environments, as well as ways to repair hearing loss. The Noise Induced Hearing Loss program's mission is to enable sailors to maintain full hearing functions over their lifetime.

NUMBERS

MENTAL SKILLS TRAINING

Preparing Future Warfighters for Operational Stress

Dr. Roy Stripling – ONR Program Officer, Human Performance Training and Education
Dr. Karl Van Orden – Naval Health Research Center, Science Director

Combat deployment and operations have always been a source of profound and intense psychological stress. The current operating environment is no exception. Young warfighters today are deployed into a high altitude dynamic terrain that is hot by day and cold by night. By the time they've acclimated to the environmental conditions, they're likely substantially sleep deprived and physically drained. The human terrain they are entering in today's asymmetric irregular environment is as complex as it gets. Young small-unit leaders need to interact on a daily basis with local elders and family leaders that may be two to three times their age, who do not share their customs, beliefs, values, or language, and who live in a social, economic, and political world so unstable that their affiliations can change from day to day. So the guy that a young Platoon leader is talking to may be his ally today, his adversary tomorrow, and his ally again the next day.

The volatility, uncertainty, complexity, and ambiguity of this situation are an intense source of stress on the warfighter. The stress response that humans naturally produce can take on two forms: acute and chronic. Both of these stress responses can be helpful when experienced in moderation, but both can contribute to mission failure and/or lasting emotional and psychological injury when the response is too intense or too long lasting. The Human Performance, Training & Education Thrust in ONR's Code 30 (Expeditionary Maneuver Warfare and Combating Terrorism Department) is looking at new ways of measuring acute and chronic stress responses, and methods for managing stress responses during combat operations to allow for enhanced resilience during wartime.

Acute stress responses trigger a hormonal response that alters a number of bodily functions for a short period of time. These typically include an increase in heart rate and respiration, increased blood flow to skeletal muscles, increased release of glucose into the blood stream, decreased blood flow to the gut (slowing digestion), and decreased appetite. As the response grows stronger these effects become more pronounced and additional effects become more apparent, including increased attentional narrowing (ultimately leading to "tunnel vision" and "tunnel hearing"), increased reliance on habitual and automatic behaviors, and decreased flexible thinking and reasoning. In a short-term, crisis situation even these extreme effects can be beneficial if the individual's training has ingrained the habitual or automatic behaviors they need to achieve success in that moment. (Imagine "instinctively" swerving to avoid an obstacle that unexpectedly appears in the road ahead of you.) However, crisis situations in combat, especially in asymmetric irregular combat, are often more complex and long lasting than simple automatic behaviors can handle.

Chronic stress responses arise when individuals perceive that they are exposed to a continuing threat that they cannot readily control or influence. Eventually, the hormonal checks and balances that normally help acutely stressed individuals return to a resting state become depleted or shut-down. Individuals get stuck in a state of higher vigilance and reduced flexible

reasoning. Their physiology shifts to a chronic state of catabolism, where their muscles slowly breakdown in order to provide a ready energy source for the crisis event that feels like it could happen at any moment. With the restorative "rest and digest" hormonal response shut down, it can be difficult for these individuals to return to their resting, regenerative state even when they know the threat no longer exists.

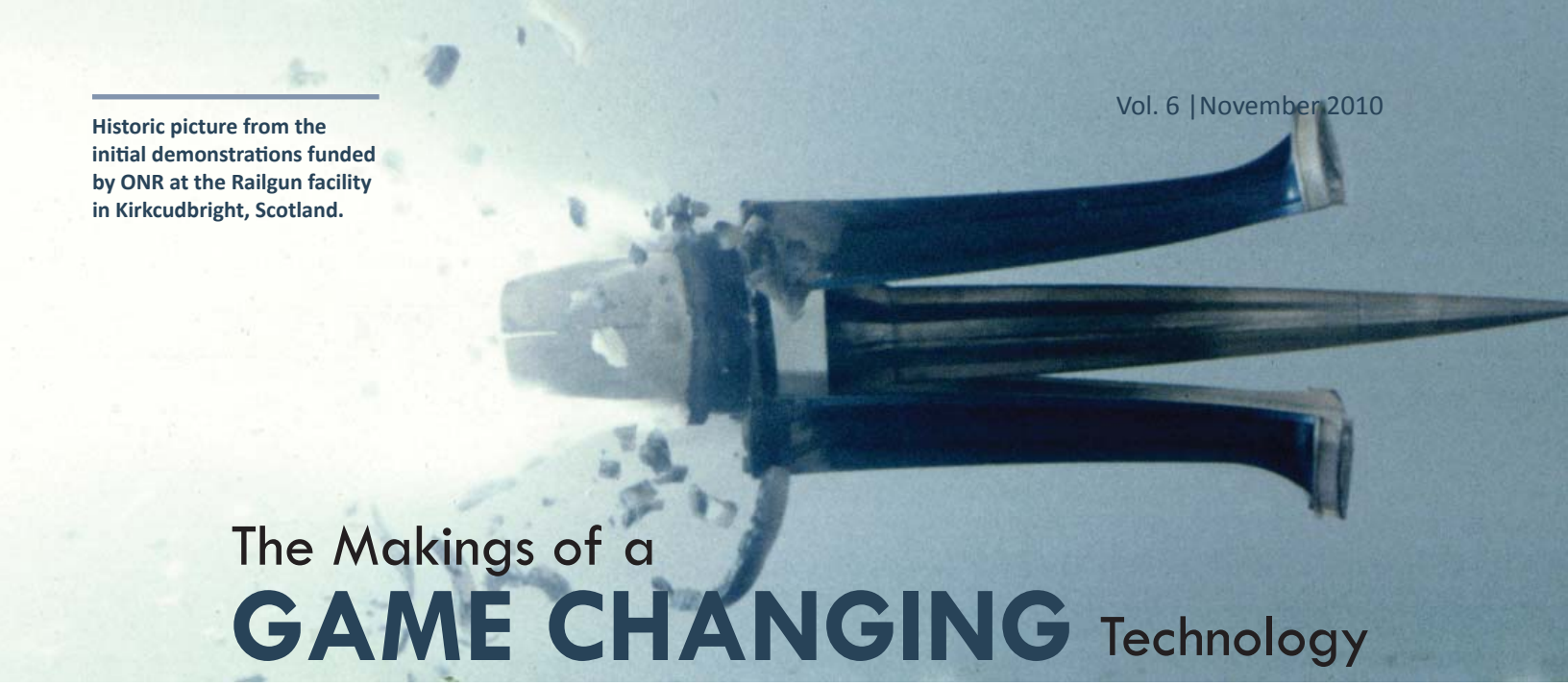
Clearly, effective management of both the acute and chronic stress responses is critical to mission success and mental health. The good news is that because an individual's perception of threat and his ability to control and influence that threat is so central to his stress response, learned behavioral skills and habits can be a very effective way to control the stress response. In fact, some elements of the traditional military culture already support good stress response management. Unit cohesion and interdependence, maintaining troop morale, and high-quality leadership are all critical for keeping individual stress responses in check.

More recent research has identified other behavioral skills that provide the individual more tools to regulate his or her stress response. These include short-term methods to limit the acute response. Controlled breathing reduces respiration and heart rate, and shifts attentional focus onto something that is both controllable and non-threatening. Positive imagery and self-talk may invoke memories or images of success and reinforce mental states associated with controlled and less threatening stimuli. Long-term strategies for coping with chronic stress also include effective goal-setting, which breaks down what appears to be a persistent and irresolvable threat into shorter, smaller goals that are more amenable to control and influence, and that can be achieved more quickly and easily. Experiencing success is a key trigger for activating the restorative "rest and digest" hormonal response and thus achieving success with short-term goals helps keep this system from getting shut down in the first place.

Marines discuss issues with local village leaders.

The Office of Naval Research is working with the Marine Corps to determine if these laboratory-validated stress response management skills will work in the extreme stress environments of asymmetric irregular warfare. Current plans are to integrate training in the use of these skills with the high intensity immersive training of the Infantry Immersion Trainer at Camp Pendleton. Subjects in these studies will be followed through their pre-deployment training and interviewed again after return from deployment to determine when they put the skills to use, whether they found the skills useful, and whether those receiving the training exhibit more controlled stress responses and better long-term mental health.

These studies will also assess neurophysiological responses to stress stimuli to determine if there are different ways that individuals mentally use and respond to behavioral stress management skills. Previous studies have identified a few genetic differences in laboratory animals that appear related to how well they deal with stressful situations. Humans also show individual differences when it comes to their ability to cope with stress. It may be that some behavioral strategies work better with people who are naturally better at coping with stress, and that other strategies are better for those who have a naturally strong stress response. Ultimately, we expect that the stress management strategies that work in the extremely stressful, asymmetric irregular combat environment will be effective in any warfighting environment and will thus benefit all warfighters. The hope is that this program will allow our future warfighters to be mentally and emotionally ready to deploy anywhere in the world on short notice, complete their mission efficiently and effectively under any extreme of condition, and then be mentally and emotionally ready for their return home. ■



Historic picture from the initial demonstrations funded by ONR at the Railgun facility in Kirkcudbright, Scotland.

The Makings of a GAME CHANGING Technology

Mr. Roger Ellis – ONR Research Program Officer, Electromagnetic Railgun, Air Warfare and Naval Weapons Applications

How does ground breaking technology go from a mere idea to a significant development effort? How do you introduce a game changing technology? How do you create something revolutionary and successfully transition it into the hands of sailors and marines? The Electromagnetic Railgun (EMRG) or simply, Railgun, is a high-risk, high-payoff technology that is intended to meet all of the objectives above. As you will see from the EMRG story, ideas alone rarely make it to prime time without additional enabling factors and activities.

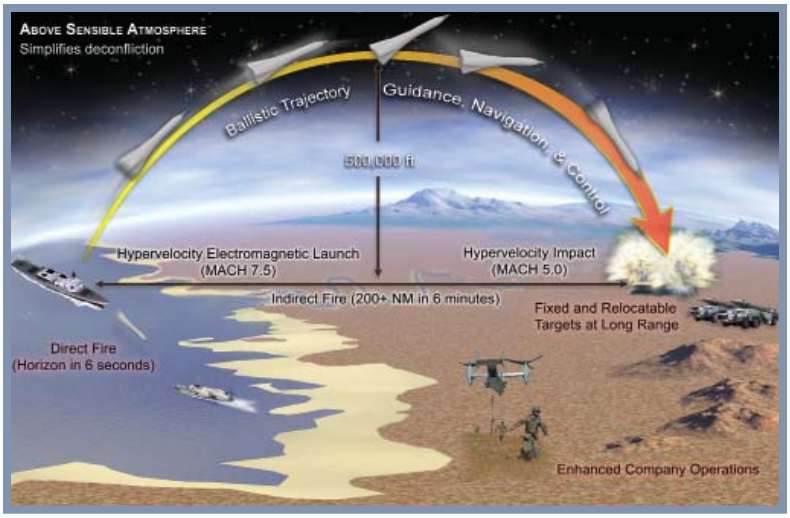
Railgun began as a concept and has grown into one of the largest science and technology (S&T) projects at the Office of Naval Research (ONR). The EMRG program is a visionary, long-range, high-energy gun system that uses electricity rather than gun powder or rocket motors to launch hypersonic projectiles. In doing so, Railgun promises to provide a potent new punch to future surface ships. When fully operational, Railgun projectiles will bolt at speeds greater than Mach 7 and strike greater than 200 nautical miles down-range in about six minutes.

This article will highlight some key factors that propelled railgun on its developmental trajectory from inception into the future. This includes timing, strategic planning, early demos, early high level vision and advocacy, stakeholder involvement, a fearless and tolerant sponsor, and a hard working and passionate team.

Strategic Planning, Early Demos and Good Timing

The current navy railgun effort began in 2001 when RADM Charlie Hamilton, Program Executive Officer, Ships (PEO Ships), asked for ideas using the massive electric generating capacity of DD-21 for a generation of new electric weapons. This pivotal question followed a report conducted by the Chief of Naval Operations (CNO) Strategic Studies Group (SSG), envisioning the advantages and potential of electromagnetic railgun technology. Late that year, ONR, PEO Ships, and Naval Surface Warfare Center (NSWC) Dahlgren co-sponsored an electromagentic railgun workshop hosted by the Institute for Advanced Technology at the University of Texas at Austin. The intent of this workshop was to gather the nation's subject matter experts, stakeholders, and skeptics to determine if the development of an operational railgun system was indeed technically feasible. The result was resoundingly in the affirmative.

In 2002 Admiral Robert Natter, Commander, Fleet Forces Command, agreed to fund a series of demonstrations at the railgun facility in Kirkcudbright, Scotland. These early demonstrations of electromagnetic launch technology were extremely important in building a basis for vision of the possibilities and consensus among key



Conceptual design depicting the Electromagnetic Railgun program

stakeholders including RADM Jay Cohen, who was the current Chief of Naval Research (CNR) at the time, and NSWC Dahlgren technical leadership. The enthusiastic support of Mr. Thomas Pendergraft, NSWC Dahlgren Technical Director, prompted NSWC to fight for and to internally fund the initial test facility building in 2004.

The Naval Warfare Development Command completed an analysis of railgun employment and in 2006 published the Railgun Operating Concept. This forward-looking operational document proved to be an important catalyst for illuminating the operational advantages of the Railgun. It has provided the use-case guidance to numerous analytic efforts including wargames, exercises and detailed lethality analysis. It has been especially useful for communicating the operational advantages and vision of Railgun to the warfighter community.

High-Level Vision and Advocacy

Admiral James Hogg head of the CNO SSG and Dr. Hans Mark, former Secretary of the Air Force provided critical advocacy and mentorship to the nascent Naval Railgun program. Admiral Hogg was among the first senior leaders to grasp the game changing potential of the Railgun system. He and Dr. Mark were the critical visionaries who communicated this potential to senior navy leadership. As mentioned, ADM Natter funded the Railgun demonstrations in Kirkcudbright that illustrated the potential of the technology in the most dramatic fashion. Then CNO, ADM Vern Clark, told a gathering of Army officers in 2004 "The future is we're going to have Railgun one of these days — Railgun's going to go 200 or 300 [miles]. You know, we're going to have it! You Army guys are going to like this…We're spending S&T on it and that's where we're headed."

High Risk Tolerant Sponsors and Stakeholders

2005 brought further progress and support when the Department of the Navy S&T Corporate Board designated

Admiral Robert Natter loading the gun as RADM Jay Cohen (former Chief of Naval Research) observes

32 Megajoule Electromagnetic Launch Facility at Naval Surface Warfare Center, Dahlgren Division

the railgun project as the inaugural Innovative Naval Prototype (INP) and assigned ONR to conduct a proof-of-concept demonstration during a multi-year effort for about $250M. ONR's Innovative Naval Prototypes (INPs) are by design high risk, high payoff, and high dollar commitment efforts. At the same time the EMRG Executive Steering Committee (ESC), chaired by the Commander, Naval Sea Systems Command was chartered to monitor progress and to make periodic reports to the Assistant Secretary of the Navy for Research, Development and Acquisition (ASN RDA) and to CNO Resources, Requirements and Assessments (OPNAV N8). The ESC is comprised of key stakeholders including acquisition, sponsor, and user communities. This board is closely involved in the progress and challenges of developing this cutting edge technology. They are well informed on the successes as well as the inevitable surprises that cutting edge technology often presents. In fact, it is the open and honest assessments of occasional failures that has built the trust and confidence of this key group that Railgun is on the right track and will succeed.

Fast Advancing Technology

Cranking up the launch energy while extending barrel life is the daunting task and challenge of the present effort. During the four years since testing began at the Electromagnetic Launch Facility, 630 high energy shots have been fired. This compares with 367 shots at other US and allied facilities during the previous 14 years. State of the art launch energy has tripled during the past four years to greater than 24 megajoules (MJ) while barrel life has advanced from tens of shots to hundreds of shots. The program expects to celebrate a new world record gun firing at 32 MJ muzzle energy in December, an expected fourfold increase from where we started in 2006.

The Electromagnetic Launch Facility went into service late in 2006 and the rapid march up the learning curve naturally followed. The current phase ending in 2011 will culminate in 32 MJ test demonstrations of two tactical style launchers designed and built by industry partners BAE Systems and General Atomics. The 32 MJ lab launcher will demonstrate the best of breed barrel life and serve as the basis for going forward into the next phase. Government and industry partners working closely together have proven to be a key enabler for rapid advancement.

Eye Towards Future

Plans are underway to shape the next phase of the project. The Corporate S&T Board has approved an INP Phase II from 2012 through 2017. A key technical aspect of the next phase will be solving the challenges of heat removal during high rates of fire. Firing rate during the first phase of the program has been on the order of a half dozen shots per day. In the next phase we will be striving for a half dozen shots per minute. This increase in shot tempo presents many S&T challenges.

Close coordination with Naval Sea Systems Command (NAVSEA) in order to support an at sea demonstration will continue to be emphasized. This close integration will help assure a smooth transition to acquisition. During Phase II, preparations for shipboard integration will step into full swing, particularly looking forward to future ship variants such as the DDG 51 class. Efforts to develop a suitable projectile demonstration of a full railgun system will also be needed.

To Infinity and Beyond

In addition to good technology development, the path from promising concept to experimental hardware and ultimately into the hands of sailors, also takes strategic planning, committed stakeholders, and a continual eye towards the future. Most importantly, it takes visionary leaders with the staying power to see the task through. As the EMRG program moves forward, it is critical to the livelihood of this effort that it continues to receive insight and guidance from senior leadership, stakeholders, and researchers. To become a game changing technology, EMRG needs to be further developed and transitioned onto the Ship of the Future and into the hands of our sailors and marines, ultimately changing the way we fight and win wars. ■

HEARING LOSS

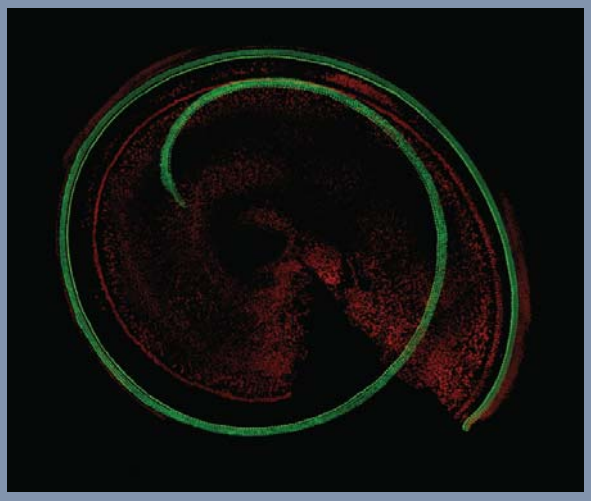
PROTECTING OUR SAILORS AND MARINES THROUGH NOISE INDUCED HEARING LOSS RESEARCH

Mr. Kurt Yankaskas – ONR Program Officer, Noise Induced Hearing Loss, Warfighter Performance Division

The US Navy's ship of the future will feature significant changes in technology, construction methods, weapons systems, propulsion systems, sensors systems, communications, etc. These vessels will also provide a safer environment for the important component: the crew. Currently, the largest growth in the number of injury claims with the Veteran's Administration involve noise induced hearing loss and tinnitus, making excessive noise levels one of the most prominent hazards of duty onboard Navy vessels. The ship and the Navy of the future will employ a variety of new technologies in order to reduce this trend and protect the crews.

As new recruits enter the Navy, their hearing health will be measured and stored via a digitized and more objective system than the current audiogram. This information becomes the sailor's baseline and will stay with him/her throughout their Navy career. In order to better protect their hearing during their time on duty, the Office of Naval Research (ONR), in conjunction with Naval Sea Systems Command and Naval Air Systems Command (NAVAIR) is currently developing two advanced hearing protection systems, the custom molded earplug and the new flight deck cranial.

The days of the yellow "foamy" earplug are clearly numbered. Studies performed by NAVAIR have demonstrated that advertised Noise Reduction Ratings that are obtained under laboratory conditions do not match up to "real life" scenarios. Plus, the vast majority of sailors are not inserting the plugs deep enough to obtain the maximum noise attenuation. The replacement technology is a custom molded earplug fitted to each individual sailor. Multiple depths of ear canal insertion are available with deep insertion varieties demonstrating up to 50 decibels attenuation. The depth of insertion



The tiny green dots depicted in this image are the hair cells in the cochlea of a neonatal mouse, a part of ongoing research being conducted to regrow hair cells. (Image courtesy of St. Jude Children's Research Hospital)

can be tuned to the expected ambient noise levels. For instance, flight deck personnel will be fitted with the deepest models, maximizing attenuation in that very high noise environment. To provide a quieter environment during off duty and sleep hours a lesser attenuation plug is available. This allows for improved hearing recovery time. Trained personnel, using a quick setting mold material inserted into the ear canal, currently perform fitment. However, a new method currently under study by ONR would utilize a probe, which produces a digital map of the ear canal. This process will greatly improve the logistical efficiency of providing every sailor with custom molded plugs and simplify the storage of thousands of ear canal records.

The custom molded earplug can also be upgraded electronically. Active Noise Reduction

can be added for further noise attenuation. Communications capability can be added to facilitate command, control and information dispersal in high noise environments, such as the flight deck. For weapons operators, including Marines, microphones supply the earplugs with ambient sounds, increasing situational awareness, while the embedded software limits exposure to high noise levels or impulse noises such as weapons firings or explosive devices. These various electronic capabilities can also be combined, based on the noise environment and the operations being performed.

A new flight deck cranial is being developed by NAVAIR and ONR that will provide greatly improved hearing protection, impact protection, will be compatible with Night Vision Devices and Chemical, Biological and Radiation protection equipment. This new cranial will also provide improved protection against bone conduction of noise which becomes the dominant noise pathway at the high noise levels encountered on the flight deck and a more individualized fit system to ensure each user is obtaining the maximum benefit of the new design. New improved materials for personal hearing protection are also being researched.

Improved personal hearing protection is one part of the solution to noise induced hearing loss. Another aspect currently under study at ONR is the reduction of noise levels in the environment the sailors live and work in: the ship. The key to reducing noise levels aboard future vessels is a complete systems approach, looking at every aspect of design and operations. A new software package, known as Designer Noise, is being developed under an ONR contract. Designer Noise is a prediction and analysis tool that can be used to upgrade or improve a vessel design to reduce noise and vibration levels. Given the inputs of ship geometry, construction details and acoustic source levels, this software can predict noise levels by compartment while the vessel is still in the design phase. This provides the designer with information that can be used to dramatically lower shipboard noise levels before construction begins. Various iterations can be quickly traded to determine the optimum design that will protect sailors hearing while meeting all the other performance criteria for that particular ship design.

A systems integrated approach to reducing noise levels aboard ship will also include three different areas of consideration.

1) Reduction of source noise.

   The reduction of source is potentially the most efficient means of vessel noise control. By limiting the generation of noise and vibrational energy before it is propagated through the ship's structure, less damping or absorbing material will be required to lower noise levels in specific compartments, saving money and reducing the ship's overall mass. Also, in many instances, noise is a sign of inefficiency and wasted energy. For example, a duct that generates turbulent airflow is not only noisy, but requires additional power to operate than a duct with a smoother airflow. One technology currently under study is Isotropic Superfinishing, a chemical/mechanical process that polishes metal surfaces to very fine tolerances, reducing friction and, therefore, noise. Especially useful in transmission gears, heat and power loss are also reduced, resulting in a more efficient power train. NAVAIR and ONR are also researching various methods to reduce the noise levels generated by tactical aircraft jet engines, which would lessen the exposure levels for flight deck personnel. Designing future vessels with turbine intake ducts and ventilation ducts that are more efficient and integrated with the overall ship design and taking advantage of processes and technologies that reduced source will result in a quieter, more efficient ship.

2) Insulation and isolation.

   Insulation and isolation refers to the blocking of noise and vibration transmission pathways with the use of damping materials and technologies. For instance, the insulation of a compartment to limit the intrusion

of noise from another space or the use of vibration isolation mounts on machinery to limit the transmission of vibration to the ship's structure and the propagation of that vibration to other areas. In conjunction with design tools such as Designer Noise, which can help optimize the amount and placement of damping materials, new insulation materials are currently being developed. TempCoat is a spray applied insulation material originally developed to reduce condensation on bulkheads and other surfaces. It also demonstrates good noise damping qualities while requiring relatively little addition in vessel mass and is easily applied compared to other damping materials, so fewer man hours (and less cost) are required.

The commercial sector is developing improved isolation mounting systems that are very tunable to specific machinery masses and vibrational modes. Increased use of such technologies will reduce the amount of vibrational energy transmitted to the ship's structure, reducing noise levels and the amount of insulation materials required to reduce noise levels in inhabited compartments.

3) Operations.

Some current crew activities in high noise environments can be performed with remote sensing or robotic technologies. Basically, if the sailor doesn't absolutely have to be in that environment, remove him/her and perform that function with hardware that is not adversely affected by high noise levels. Much of the technology required already exists and some will have to be developed, but this method will reduce the number crewmen experiencing hearing loss and/or tinnitus.

The Navy's ship of the future will take advantage of advances in technology in multiple areas, which will include improved protection of sailor's hearing. And a quiet vessel has a tactical advantage over a noisy vessel. ■

UPCOMING EVENT

ONR Distinguished Lecture Series featuring Dr. Peter Warren (PW) Singer, Senior Fellow and Director of the 21st Century Defense Initiative, Brookings Institution. Dr. Singer is considered one of the world's leading experts on changes in 21st century warfare. He has written for a wide range of journals and is the author of three books covering the privatization of the military industry, children in war, and most recently, robotics and new technologies for war titled, "Wired for War". His talk will take place at the Office of Naval Research on Thursday, December 16, 2010 from 1330-1500 and will be streamed live via Defense Media Activity's website, Armed with Science: http://science.dodlive.mil/ ■

Dr. Peter Warren (PW) Singer, the next ONR Distinguished Lecture Series guest speaker

WATCH

former ONR Distinguished Lecturers:

Dr. Michael Posner	http://bit.ly/cCZPR4
Dr. William Phillips	http://bit.ly/bbs8Uj
Dr. Werner Dahm	http://bit.ly/9UPJOJ
Innovation in China	http://bit.ly/aktwu2
Innovation in Brazil	http://bit.ly/a8lndu

MAINTENANCE FREE SHIP TECHNOLOGIES: A REVOLUTION IN THE NEED AND TEMPO OF FLEET MAINTENANCE

Dr. Airan Perez – ONR Program Officer, Maintenance Free Ship Technologies, Sea Platforms and Weapons Division

Several studies and panels have recently concluded that corrosion and related maintenance activities are a significant cost burden to the US military and specifically, to the US Navy. A study entitled "The Annual Cost of Corrosion for Navy Ships, *2006-2007 Update*"[2] showed that the Navy expended $3.2 billion annually on corrosion related ship maintenance alone. Further, an external analysis of science and technology investment portfolios for the Office of Naval Research (ONR) concluded the potential return on investment for directed research in condition based maintenance, corrosion control, and wear resistance would far surpass similar investments in fuel efficiency.[3] The analysis recommended more emphasis on projects that address reducing maintenance labor and material and manufacturing costs.

But what if you could do away with corrosion related maintenance altogether? This simple question ignited the development of Maintenance Free Ship Technologies. The concept of "Maintenance Free Ship" directly addresses some of the more pervasive maintenance issues and cost-drivers with innovative solutions. These technologies are intended to provide a dramatic reduction in depot, sailor workload, and likewise, improvements in operational availability. While many programs within ONR and even the Defense Advanced Research Projects Agency (DARPA) have looked to address these key maintenance issues, they are largely incremental improvements conducted within the limitations of existing ship design. Maintenance Free Ship technologies look beyond the increment and view to transform how we build and maintain ships.

The objective of the Maintenance Free Ship Technologies effort is to utilize recent technology advancements to meet the enduring maintenance needs of Navy ships. Two high cost driver areas are targeted for ONR's first investment into this concept. These are underwater hull maintenance and shaft maintenance. ONR has put together a team of experts from the Naval Research Laboratory (NRL), and Naval Surface Warfare Center Carderock Division, to lead the effort.

The underwater hulls of Navy ships have three key components for corrosion and biological fouling control: (1) Cathodic Protection (CP) to protect exposed metallic materials; (2) an anti-corrosion coating (AC) system to reduce exposed bare metallic surface area; and (3) an anti-fouling (AF) coating system to minimize the effects of biological growth that increases drag and fuel consumption. From a hull maintenance perspective, each is an independent system having a straight forward function and purpose. The objective of the Integrated Underwater Hull System (IUHS) is to simplify the corrosion control process by combining all three functionalities into a single complex distributed system. In addition, threat detection capabilities based on underwater electric potential variations due to an intruder will be added. The laboratory scale proof of concepts for IUHS components will consist of experimental efforts focused on the performance of individual candidate components. NRL has significant experience in Impressed Current Cathodic Protection (ICCP) components and system design and it is planned that the development

[2] LMI Report, Arlington, VA, January 2010

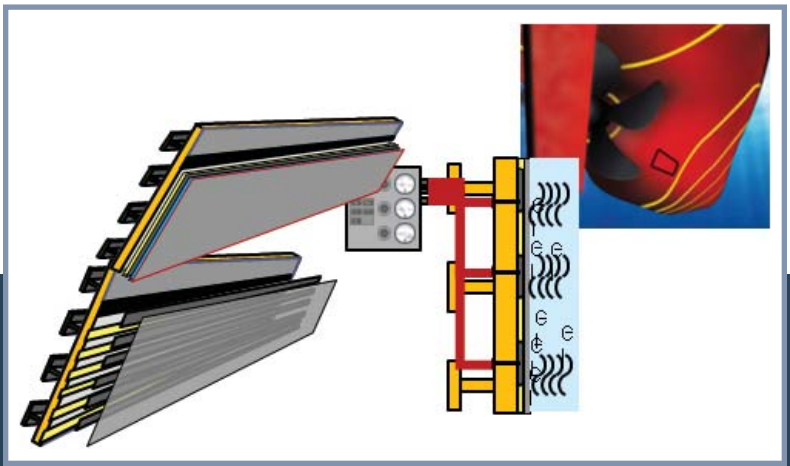
[3] Center for Naval Analysis, Alexandria, VA, 2008

proceeds in stages to provide stepwise proof of concept for each key feature of the system. A combination of experimental and computational approaches will be used throughout the development. The highlight of the first year effort in the IUHS will be the laboratory scale proof of concept of an integrated system. The plan is bold and novel.

The second high cost driver targeted by ONR in Maintenance Free Ship Technologies is the main propulsion shaft. The main propulsion shaft is a critical component of the ship, as it must provide mobility, a critical mission profile need. One of the primary failure modes of the shaft is corrosion of the areas that are adjacent to the bearings. Systematic studies of the failure mechanisms will be completed to determine root cause. Selection of emergent technologies for further laboratory evaluation will be based on root cause rather than a symptomatic understanding of the problem.

A number of potential technological areas are anticipated for evaluation based on an initial assessment of current research and development efforts. An improvement in the existing "covering" method using advancements in adhesive and coating systems developed in part by the ONR Future Naval Capabilities program on rudder coatings is one area of consideration. Significant improvements have been made in this area which would afford an improvement over the extant fiberglass wrap that degrades over time. A second promising area is new materials. Considerable effort has been expended in the development of a composite shaft that would not be subject to electrochemical degradation. Other materials that offer similar torque properties with reduced corrosion susceptibility will also be considered. Surface treatments offer a third area of consideration that will be considered. Hardening using electron or laser beam treatments have the potential to enhance the corrosion resistance of the surface layer to a depth sufficient or with sufficient dielectric to offset electrochemical action. A final area is to use directed sensing with an impressed current to provide an alternate source of electrons to offset the electrochemical effect on the metal shaft. This effort would leverage advancing work that has been performed in the development of current sensors and shaft grounding device technologies. Laboratory demonstrations will be used to validate individual components and/or materials followed by a field evaluation at either a shaft mock-up facility or on a research vessel, as has been done with previous shaft longevity evaluations.

Maintenance Free Ship Technologies offer the potential to revolutionize the need and tempo of fleet maintenance. The proposed technological innovations have cross-platform versatility and functionality. If successful, the implementation of the developed technologies will provide an order of magnitude leap ahead in total ownership cost reduction and improved operational readiness due to the increased availability of the ship to operational mission tasking. ■



Integrated Hull Shield: Active Corrosion Control with Electrolytic Halogenation for Fouling Control and Threat Detection

INTEGRATED TOPSIDE
DYNAMIC CONTROL OF THE RF SPECTRUM IN THE FUTURE BATTLESPACE

Ms. Betsy DeLong – ONR Program Officer, Integrated Topside

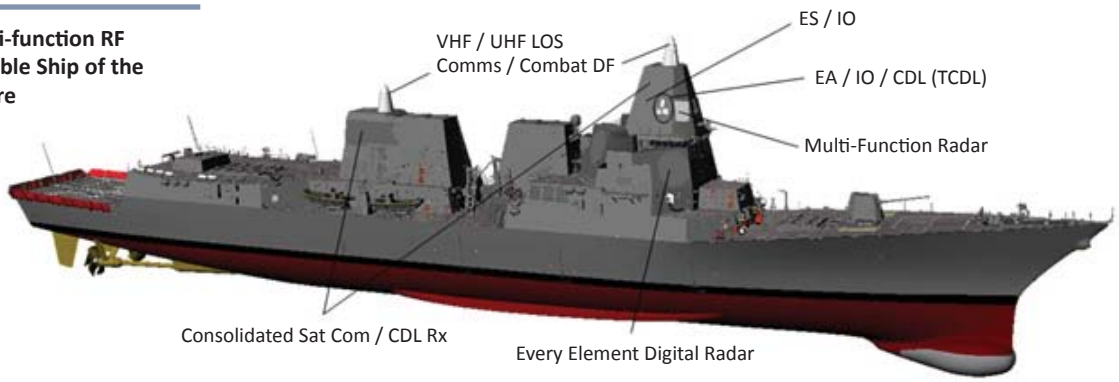
Integrated Topside (InTop) is an Innovative Naval Prototype (INP) program established by the Office of Naval Research (ONR) to develop an integrated, multifunctional system of electronic warfare (EW), radar, information operations (IO), and communications capabilities that can be scaled and adapted to multiple classes of Navy ships and submarines. A key characteristic is dynamic management of the radio frequency (RF) spectrum through a Resource Allocation Manager that will allow the system to instantaneously meet the highest priority needs while meeting overall platform RF requirements. At the heart of the InTop program is the development of a modular, open architecture that allows for growth and change as technologies and Navy needs evolve.

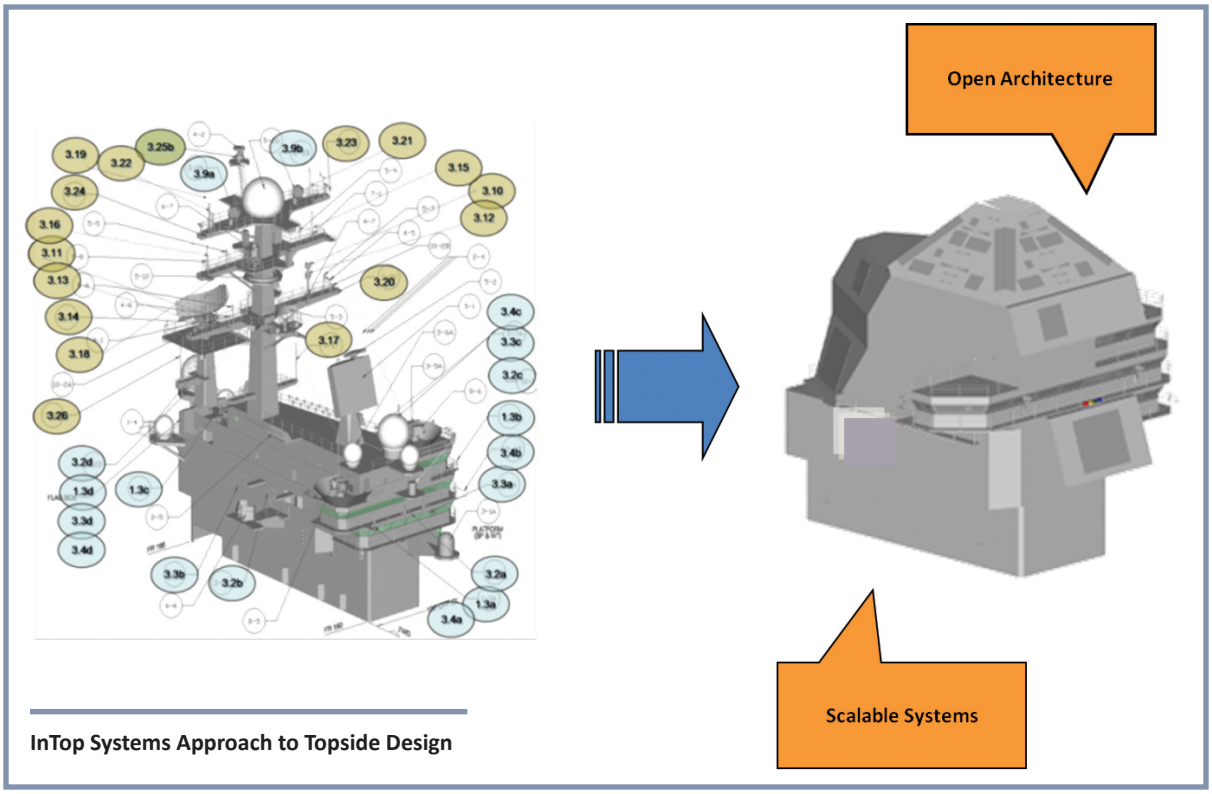
Today, ship radar, EW, IO and communications equipment have their own apertures, electronics, operators, logistics, and maintenance needs. This adds to life cycle costs, weight, space and power demands on ships. It also results in larger RF interference issues and increased ship radar cross sections, thus reducing stealth. To counter these issues, InTop will provide adaptable RF capabilities by developing integrated sensors and communication solutions that are affordable, open, modular, and scalable.

The genesis of InTop was the Advanced Multi-function RF Concept (AMRFC) System, a solid state technology demonstrator that proved the concept that multi-function RF systems could be developed and could enhance operational capability. Additionally, fleet needs for additional EW and communications capability, the recognition that there was an overcrowding of sensors on ships and impressive progress in solid state technology development and RF design tools have all combined to drive the need for affordable and innovative ways to develop and implement RF systems. To date, the Multi-function EW System, the InTop Wideband Satellite Communications Antenna Subsystem and the InTop EW/IO/Comms Advanced Development Models are direct outgrowths of AMRFC.

By designing InTop with an open architecture, it will be possible to extend the life of the systems and sensors through multiple technological advances and potentially for the full lifespan of our ships. Since open architecture can be difficult to achieve, the InTop program has employed five contractor/Navy teams to

Multi-function RF Capable Ship of the Future





InTop Systems Approach to Topside Design

develop a notional architecture and interfaces and will soon include System Engineering and Integration as an area of study. Areas covered by the current four teams are:

1. Apertures
2. Radio Frequency/Intermediate Frequency
3. Digital Signal Processor and Data Processing/Software
4. Resource Allocation Manager/Software/ Combat System

By using this approach, it allows for the infusion of innovation over time, which enables attendant increased competition, leveraging of commercial investments, increased supplier base, enhanced commonality and reduced cost. ■

WATCH

Referenced in the article on page 8, watch the EMRG fired at the NSWC Dahlgren Launch Facility...

http://www.navsea.navy.mil/nswc/dahlgren/ET/railgun/default.aspx

From the article on page 18, watch the video of the Innovation in Brazil lecture...

http://science.dodlive.mil/2010/10/18/international-lecture-series-the-arrival-of-brazil/

ONR LECTURE SERIES FOCUSES ON BRAZIL'S GROWTH IN GLOBAL SCIENCE AND TECHNOLOGY

Mr. Geoff S. Fein – ONR Corporate Strategic Communications

Brazil's efforts to increase government investment in science and technology, as well expand its global presence, were the focus of the third Office of Naval Research (ONR)–sponsored International Lecture Series held Oct. 18 at the organization's corporate headquarters.

"The Arrival of Brazil" lecture featured Dr. William Melton, surface ship coordinator, Naval Surface Warfare Center, Carderock; Dr. Eugenius Kaszkurewicz, director of scientific development and technological financier of studies and projects (FINEP), ministry of science and technology; Dr. Fernando Rizzo, director, Center for Strategic Studies and Management: science, technology and innovation; and Dr. Jaime Fretias, electronic science and technology research, US Naval Research Laboratory.

Brazil has steadily risen over the years to become an innovative force in the international community, said Dr. Larry Schuette, ONR's director of innovation, and sponsor of the lecture.

"With favorable macroeconomic conditions and the introduction of national science, technology and innovation policy as a government priority, Brazil is a country that we should continue to watch, learn from and identify shared interests to partner in," Schuette said.

These lectures help ONR understand and identify emerging science and technology (S&T), and build relationships with the external research community, Schuette said. They also inspire and challenge ONR's program officers to pursue world-class research. The Office of Innovation promotes, fosters and develops innovative science, technology, processes and policies that support the Department of the Navy. ONR's lecture series features leaders in innovation, from a global, academia and military perspective. They are intended to open the aperture to the innovative research being conducted across the globe, Schuette said.

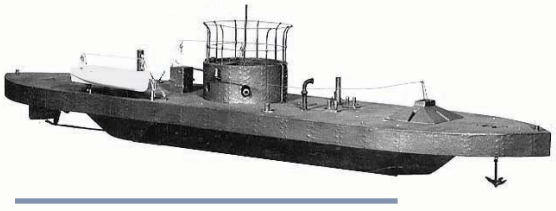
Lecture speaker Kaszkurewicz told attendees there are opportune areas for Brazil and the United States to partner in S&T, including advanced materials; biotechnologies and nanotechnologies; chip design; climate change; health and space; and defense. While Brazil is taking its approach to S&T seriously, its government is investing 1.2 percent of its gross domestic product in S&T, lecture speaker Kaszkurewic said, adding more needs to be done in the coming decade. He noted, for example, the country lags in high-technology exports: "The main objective of [Brazil's] science, technology and innovation investments is to push that line to the right."

Dr. Eugenius Kaszkurewicz points out Brazil's scientific landscape during the ONR International Symposium focused on innovation in Brazil. (U.S. Navy photo by John F. Williams/RELEASED)

ONR's previous international lectures have explored innovation in China and India. The next lecture series is scheduled from 1:30 p.m. to 3 p.m. December 16 at ONR, and will feature Peter W. Singer, director of the 21st Century Defense Initiative, a senior fellow in Foreign Policy at the Brookings Institution and author of "Wired for War: The Robotics Revolution and Conflict in the 21st Century." ■

DIRECTOR'S CORNER

Dr. Larry Schuette – ONR Director of Innovation



A model of the first USS *Monitor,* 1861

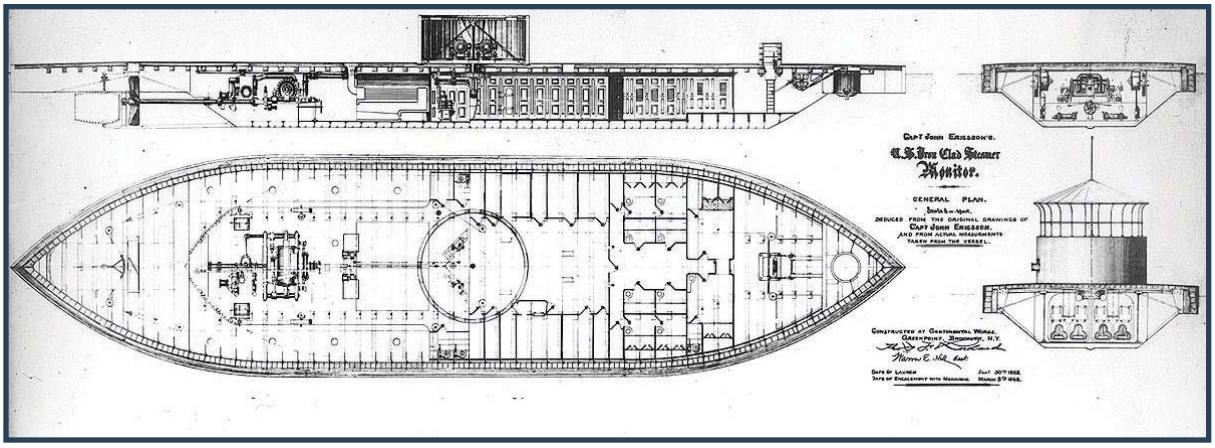
On October 13, 2010 we celebrated the Navy's 235th birthday. Throughout the history of Navy shipbuilding, innovation has thrived: moving forward from sail to steam and then from diesel to nuclear has been a journey filled with revolutionary advances. Today our Navy is unparalleled around the globe, and many of the innovations we have seen were realized in our pursuit of greatness.

The US Navy moved from sail to steam with the delivery of the Fulton in 1814. But with many of our innovations, the potential of steam propulsion wasn't realized with the Fulton. The *Monitor* is commonly recognized as the ship that took us into that new era of the "ironclad" ships. The *Monitor* was built in 1862, and the era of the ironclad began and was an integral part of our rise as an economic power in the world. It would be several decades before we saw major advances in ship propulsion.

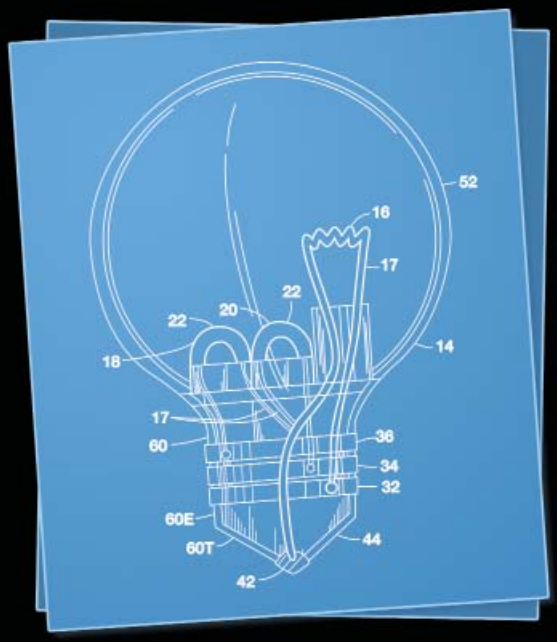
An 1888 design competition ultimately led to the construction of the USS *Holland* which employed an Otto-type gasoline engine for surface running and electric motors for submerged operations. The need for a more stable fuel in the submarine ultimately led us to the diesel engine.

Once again the submarine was destined to realize the next revolutionary step in US Navy propulsion with the introduction of nuclear power. The USS *Nautilus* was launched in 1954. She was made possible through the dedicated efforts of the Naval Research Laboratory (NRL). NRL scientist Ross Gunn was the first to conceive, propose and investigate nuclear power for propulsion in 1939. A look back in time must include the efforts of Admiral Hyman G. Rickover. Known as the "father of the nuclear Navy," he worked at Oak Ridge National Laboratory to develop a compact nuclear reactor for future submarines.

These leaps in technological progress came about through the combination of a strong technical talent, visionaries, and an overwhelming need for growth to remain a superior Navy. Today we face similar challenges that demand the attention of our talented people across the Naval Research Enterprise. In the words of Albert Einstein "To raise new questions, new possibilities, to regard old problems from a new angle, requires creative imagination and marks real advance in science." ■



Inboard plans of USS *Monitor*, published 1862 (image courtesy of the Naval History and Heritage Command)



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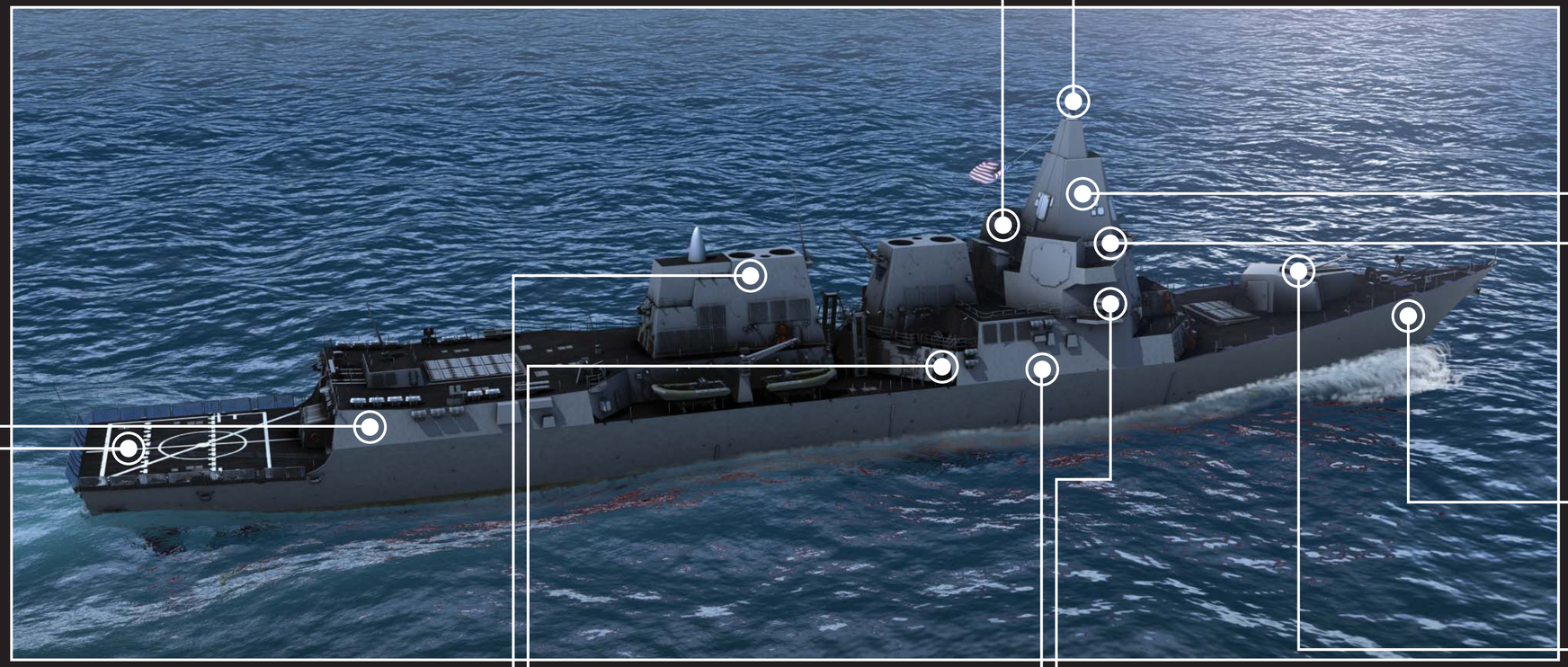
ship of the future

The Ship of the Future is a visual tool designed to educate a broad audience about the cutting edge science and technology research being executed at the Office of Naval Research. These technologies are intended to improve the infrastructure and capabilities of future Navy ships, enabling our Sailors and Marines to be safer, faster, stronger, and more agile than our adversaries. The current version of this futuristic, conceptual design features twelve different ONR technologies, including the Free Electron Laser and Electromagnetic Railgun.



Precise At Sea Ship System for Indoor-Outdoor Navigation (PASSION)

> Precise at Sea Ship System for Indoor-Outdoor Navigation (PASSION) is an emerging technology that enables wireless position tracking of both external and internal environments of naval vessels.

> PASSION meets the need for positioning systems aboard aircraft carriers and other vessels to reduce on board manning for damage control and maintenance, and for locating personnel and equipment.

High Energy Laser

> The High Energy Laser (HEL) program provides a highly effective and affordable point defense capability against multiple surface and air threats, future anti-ship cruise missiles, and swarm of small boats. A part of this program is the Free Electron Laser (FEL) system, a highly defensive technology that is all electric for a deep non-explosive magazine that provides speed of light delivery against multiple, maneuvering targets for a wide range of missions and threats.

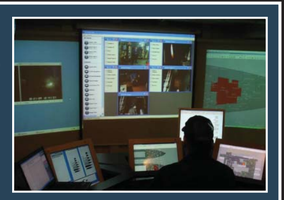
> The HEL program will improve navy ship defense against a variety of enemy capabilities. Specifically, FEL will provide low cost capabilities to defend against surface to air threats, future anti-ship cruise missiles, swarms of small boats, and is a key element to future layered defense.

Integrated Topside (INTOP)

> The Integrated Topside (INTOP) uses an integrated, multi-function, multi-beam top side aperture construct that combines electronic warfare, radar, information operations and communications capabilities to support multiple classes of ships and other Navy platforms.

> INTOP will provide the Navy dominance across the RF spectrum to meet the highest priority needs at any given time. It will also provide more capability per platform through an optimized aperture placement and space, weight and power improvements.

Advanced Damage Control Communication



> The Advanced Damage Control Communication program is an ad-hoc wireless communication system for damage control aboard navy vessels.

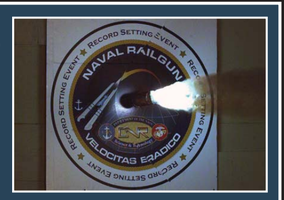
> It will improve situational awareness, provide real time information updates, and help overcome and rectify the present error prone methods of report and track.

Friction Stir Welding

> Friction Stir Welding is a new welding process that is able to weld numerous materials including, but not limited to, aluminum, bronze, copper, titanium, steel, magnesium and plastic.

> Friction Stir Welding will improve platform survivability, reduce platform weight and improve platform efficiency at a reduced life cycle cost.

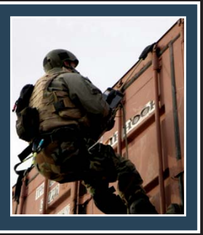
Electromagnetic Railgun



> The Electromagnetic Railgun uses electricity rather than chemical propellants to launch highly accurate, lethal-guided projectiles causing minimal collateral damage.

> It will greatly extend the range of the Navy and Marine Corps combat capabilities including enhanced company operations and improved safety aboard ships. The railgun will also simplify logistics due to scalable effects, deep magazines and insensitive munitions.

Powered Rope Ascender



> The Powered Rope Ascender is an ascending device that is suitable for Visit Board and Seizure teams, remote casualty evacuation, helicopter extraction operations, and mountain warfare assault teams.

> The Powered Rope Ascender will reduce user fatigue, increase efficiency and speed, and will allow greater opportunities for helicopter extraction missions.

Rapid Cure Tank Coatings

> Rapid Cure Tank Coatings are a new type of coatings that will replace legacy solvent based tank coatings which require significant installation time, maintenance, and do not meet emergent EPA volatile organic compound regulations.

> The new coatings can be used on tanks and dry voids through ships and will extend tank life as well as reduce life time maintenance of the ship.

Advanced Surface Ship Watertight Enclosure

> A new watertight door made of corrosion-resistant steel that has an improved door sealing system and is lighter, more effective and has a lower total ownership cost than current models.

> The standard watertight door panel closures on marine vessels are often inadequate, unreliable and require significant maintenance. The new door is 27% lighter than current doors and its design reduces in-service maintenance and life cycle upkeep costs while overcoming current leakage problems.

Hybrid Drive – Propulsion Derived Ship Service

> The Hybrid Drive – Propulsion Derived Ship Service project is aimed at exploring technologies to reduce fuel consumption and enable next generation integrated power system capability. The project has two parts; the first is an Enhanced Hybrid Electric Drive (EHED) and the second is the Shipboard Energy Storage Module (SESM).

> The Hybrid Drive – Propulsion Derived Ship Service will reduce fuel consumption and ensure power system stability assisting the Navy in moving toward a greener fleet.

Torpedo Salvo Defense

> This program aims to develop innovative technology to protect ships from attack by approaching torpedo salvos.

> This technology will protect the safety and security of our sailors and marines by increasing the survivability of ships to attacking torpedoes.

High Temperature Superconducting (HTS) Degaussing

> The High Temperature Superconducting (HTS) Degaussing coil system is the first of its kind to be installed on board a naval vessel and successfully produce a full 'coil effect.' The system also delivered the first-ever measurement of a degaussing system using superconductive materials.

> HTS Degaussing provides superior degaussing over legacy copper coils, is more efficient at producing a great coil effect with less energy, and weighs nearly 50% less than copper systems at an equivalent total system cost. The weight and space savings will allow naval architects to add mission payload, additional fuel, or future systems to the ship over its lifecycle.

Revolutionary Research . . . Relevant Results